AFWL TECHNICAL OBJECTIVE NUMBER 3; CIVIL ENGINEERING RDT AND E

William D. Collier

Air Force Weapons Laboratory
Kirtland Air Force Base, New Mexico

April 1973

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TECHNICAL REPORT NO. AFWL-TR-73-88

April 1973

(Replaces portions of AFWL TOD 71-1, "Advanced Weapons and Applications")

AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base
New Mexico

AFWL-TR-73-88

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Kirtland Air Force Base
New Mexico 87117

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13 ABSTRACT

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The effectiveness of our tactical and strategic forces is greatly dependent upon the facilities that support them. The dependence of strategic forces upon the aerospace facilities (missile silos, command control centers, and large Strategic Air Command bases) on which they are located is obvious. The equal dependence of tactical forces on facilities support may not be as apparent. However, actual experience in Southeast Asia and Korea, as well as studies of tactical advanced air-mobility activities for the mid-1970s, emphasizes the importance of facilities support in determining the ability of tactical forces to carry out national policy. R&D efforts under this Technical Objective will result in improved technology and equipment which will significantly increase the mobility, survivability, and capability of the Air Force's tactical and strategic forces. While these improvements will be most visible in increasing offensive and defensive capabilities, they are equally important in the day-to-day operation of existing bases.

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FOREWORD

It is mandatory that we continue to advance technology vigorously or risk losing our technological leadership. This leadership is essential to our national security and enables the United States Air Force, in support of national policy, to maintain a distinct military advantage in aerospace power.

Attainment of our research and development goals requires the coordinated efforts of the nation's technological resources. Teamwork on the part of the Air Force laboratories and the industrial and academic research and development community in accomplishing selected technical objectives provides the foundation for the future defense of the United States.

The Air Force Technical Objective Document Program is a key factor in this endeavor. This program describes technical planning objectives to be attained for the future operational needs of the Air Force. The Technical Objective Documents (TODs) should not confine, but stimulate, your thinking. The primary purposes of our TODs are to provide planning information for independent research and development programs, improve the quality of the unsolicited proposals and R&D procurements, and encourage face-to-face discussions between non-government scientists and engineers and their Air Force counterparts. TODs are prepared and published by the Air Force laboratories; classified TODs are available from the Defense Documentation Center (DDC) and unclassified TODs are available from the National Technical Information Service (NTIS).

On behalf of the United States Air Force, you are invited to study the technical planning objectives listed in this document and to discuss them with the responsible Air Force laboratory. Your ideas and proposals, whether in response to the TODs or not, are most welcome.

This document is a compilation of information prepared by several authors, primarily in the Civil Engineering Division of the Air Force Weapons Laboratory. Any inquiries concerning information contained in this document should be addressed as follows:

AFWL/XP
Attn: Mr. Collier, TOD Focal Point
Kirtland AFB, NM 87117

The inquiry will be given prompt attention by an expert in that particular technical area.

This technical report has been reviewed and is approved.

William D. Collier
WILLIAM D. COLLIER
Project Officer

Leon F. Frick
LEON F. FRICK
Lt Colonel, USAF
Chief, Plans Office

ABSTRACT

The effectiveness of our tactical and strategic forces is greatly dependent upon the facilties that support them. The dependence of strategic forces upon the aerospace facilities (missile silos, command control centers, and large Strategic Air Command bases) on which they are located is obvious. The equal dependence of tactical forces on facilities support may not be as apparent. However, actual experience in Southeast Asia and Korea, as well as studies of tactical advanced air-mobility activities for the mid-1970s, emphasizes the importance of facilities support in determining the ability of tactical forces to carry out national policy. R&D efforts under this Technical Objective will result in improved technology and equipment which will significantly increase the mobility, survivability, and capability of the Air Force's tactical and strategic forces. While these improvements will be most visible in increasing offensive and defensive capabilities, they are equally important in the day-to-day operation of existing bases.

(Distribution Limitation Statement A)

CONTENTS

Section		Page
I	INTRODUCTION	1
	The Air Force Technical Program	1
	The Purpose of the Document	1
	How to Use This Document	1
II	AIR FORCE WEAPONS LABORATORY	6
	The Air Force Weapons Laboratory Mission	6
	Commander's Assessment of Mission	6
	Management	7
	Facilities	10
III	AFWL TECHNICAL OBJECTIVE NUMBER 3: CIVIL ENGINEERING RDT&E	14
	General Objectives	14
	Specific Goals and Technical Approaches	15

SECTION I

INTRODUCTION

1. THE AIR FORCE TECHNICAL PROGRAM

The Air Force Technical Program is dedicated to the generation of the techniques and attendant demonstration of feasibility that will provide the United States Air Force with increased operational capabilities superior to those of any potential enemy.

2. THE PURPOSE OF THE DOCUMENT

One or more Technical Objective Documents (TODs) have been prepared by each Air Force Laboratory that has responsibility for a portion of the Air Force Technical Program. TODs provide the academic and industrial R&D community with specific technical planning objectives, the attainment of which the Air Force feels is critical to maintaining aerospace superiority in the years ahead. As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective further with the scientist or engineer identified with that objective. Further, you may have completely new ideas not considered in this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would add to our store of knowledge and advance the state of the art.

3. TECHNOLOGY PLANNING METHODOLOGY

The Air Force scope of interest in science and technology is very broad, but by no means all-inclusive. The technical planning objectives state what must be done in those areas of technology which are expected to contribute to increased future operational capabilities. It is therefore appropriate to describe the planning methodology used to derive the objectives.

The planning methodology is based upon the concept of establishing goals and subsequently identifying the technology to satisfy these goals. This is a gross oversimplification of the process and requires further exploration to

fully appreciate the complexity, depth, and value of the methodology. Before discussing each of the elements of the process in detail, it should be noted that although the methodology is basically goal-oriented, it does recognize and allow for the exploitation of technological opportunities.

The accompanying chart, figure 1, shows the elements of the technology planning methodology. The process starts with defining the capabilities that are required to satisfy the National Security Objectives. This is influenced by national policy, the threat, and the environment. The desired capability is that capability necessary to accomplish a mission or sub-mission assigned to the Air Force. It is the "job to be done" without regard to the systems which can do the job and, as such, is influenced by the long-range objective of the Air Force. These desired capabilities also serve as a source of information in the formulation of research planning guidance.

Technology forecasts enable Hq USAF, the development planners at Hq AFSC and the product divisions, and the laboratory planners to postulate, through a capability analysis, numerous competitive methods for accomplishing the long-range Air Force objectives. These "ways to do the job" are called system concept possibilities.

The same organizations must apply judicious selectivity to this listing of system concept possibilities to arrive at a list of most probable systems. Mission analyses are employed to assist in the selection process and further amplified to identify technology gaps in the resulting most probable systems. The laboratories play a major role in identifying the technological deficiencies which are grouped into similar areas of technology containing common objectives. These common objectives constitute the laboratories' technology planning objectives (TPOs). The laboratory internally develops a technical plan consisting of specific efforts to satisfy the TPOs. These plans provide for responsive technology as well as technology for which a quantitative payoff cannot be calculated but appears to be very promising. This represents a source of technology opportunities.

The laboratories are also responsive to deficiencies identified in existing systems and technical problems associated with systems currently in development. Research needs identified within the TPOs are used as another source of guidance for research planning.

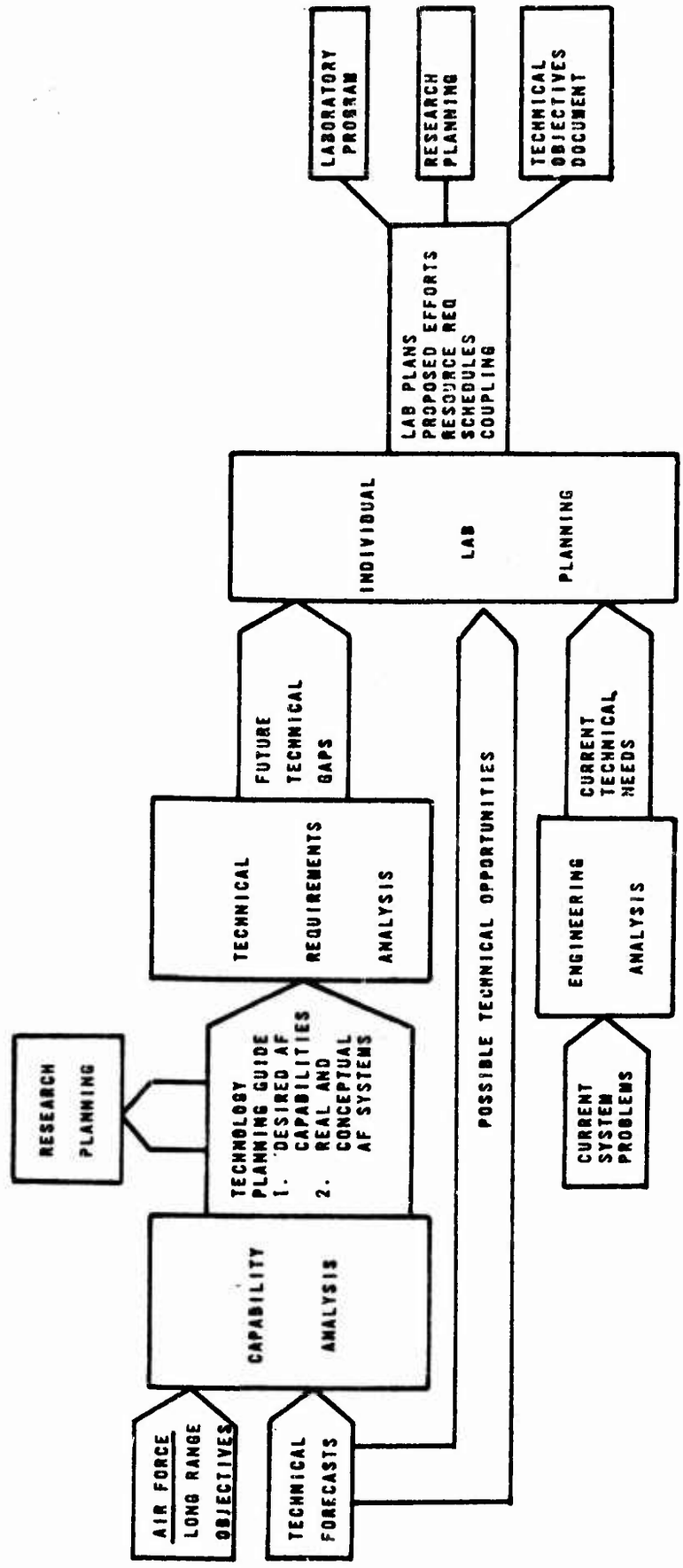

Figure 1. Technology Planning

At this point, the process provides an unconstrained technology plan based on the best guidance available with regard to needs. From the technology plan a current-year program is prepared through application of priorities and resource limitations. After the program is implemented, exploitation of the technology provides additional technological opportunities .

These same technology plans are used as the basis for the TOD program. The objective and technical approaches contained within each TPO are extracted and with only minor modifications appear in each laboratory TOD.

4. HOW TO USE THIS DOCUMENT

Unsolicited proposals to conduct programs leading to the attainment of any of the objectives presented in this document may be submitted directly to the Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact, whose name, address, and telephone number appear at the end of the technical objective. After your discussion or correspondence with the laboratory personnel, you will be better prepared to write your proposal.

As stated in the "AFSC Guide for Unsolicited Proposals" (copies of this informative guide on unsolicited proposals are available by writing to Air Force Systems Command/PPPR, Andrews Air Force Base, Washington, DC, 20334), elaborate brochures or presentations are definitely not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is extremely important that your letter be prepared to encourage its reading, to facilitate its understanding, and to impart an appreciation of the ideas you desire to convey. Specifically, your letter should include the following:

a. Name and address of your organization

b. Type of organization (profit; nonprofit)

c. Concise title and abstract of the proposed research and the statement indicating that the submission is an unsolicited proposal

d. An outline and discussion of the purpose of the research, the method of attack upon the problem, and the nature of the expected results

e. Name and research experience of the principal investigator

f. A suggestion as to the proposed starting and completion dates

g. An outline of the proposed budget, including information on equipment, facility, and personnel requirements

h. Names of any other Federal agencies receiving the proposal (this is extremely important)

i. Brief description of your facilities, particularly those which would be used in your proposed research effort

j. Brief outline of your previous work and experience in the field

k. If available, you should include a descriptive brochure and a financial statement

5. CONSTRUCTIVE SUGGESTIONS ARE ENCOURAGED

Critiques or suggestions for improving the Technical Objective Documents are encouraged; they should be directed to

Air Force Systems Command/DLXL
Andrews Air Force Base
Washington, DC 20334

SECTION II

AIR FORCE WEAPONS LABORATORY

1. THE AIR FORCE WEAPONS LABORATORY MISSION

The Air Force Weapons Laboratory (AFWL) plans and executes the USAF research and exploratory, advanced and engineering development programs associated with devices, effects, kill mechanisms, hazards, system safety criteria, and delivery techniques for nuclear, laser, and advanced weapons. AFWL plans, manages, and conducts the USAF Civil Engineering and Environmental Control RDT&E Programs. The Laboratory develops system nuclear hardness criteria and assesses the inherent hardness of Air Force weapon systems for official record. It also provides technical or management assistance in support of studies, analyses, development planning activities, acquisitions, test, evaluation, modification, and operation of aerospace systems and related equipment. AFWL provides Air Force technical support for the acquisition, weapon system integration, and retrofit of AEC-designed, developed, and produced nuclear weapons components. AFWL is designated as the DOD organization responsible for DOD/AEC interface for the conception, feasibility study, and development of Air Force nuclear weapons. It is the Air Force focal point for technical aspects of nuclear system safety.

2. COMMANDER'S ASSESSMENT OF MISSION

The broad technical mission of the Air Force Weapons Laboratory (AFWL) encompasses planning, executing, and managing the USAF exploratory and advanced development programs associated with advanced weapons.

AFWL was established in 1963 as a result of a reorganization to provide better response to the need for nuclear weapons effects research. The Nuclear Test Ban Treaty prohibiting atmospheric testing accentuated this need. Henceforth any extension of knowledge of nuclear weapons effects phenomena or of weapon system response to those phenomena must be based on theoretical analysis supported or confirmed by simulation and underground testing. AFWL has responded by intensive exploitation of theoretical approaches to the Nuclear Weapons Effects Research and Testing (NWER&T) Program.

The Defense Nuclear Agency (DNA) exercises management control over NWER&T activities of DOD. AFWL manages the Air Force portion of the NWER&T program. In accord with the USAF plan for nuclear weapons effects simulation, funded through DNA, AFWL has implemented a vigorous theoretical weapons effects simulation program.

The objective of the DOD-NWER&T program is the investigation of the nuclear weapons effects needed for a technology base to provide a capability for improving DOD weapons systems. The first efforts were to investigate, theoretically, those areas of nuclear phenomena which could be confirmed by available atmospheric nuclear test data. Because of these investigations, nuclear weapons effects at low altitudes can be predicted with high confidence. However, new concepts of nuclear weapon utilization in the higher altitudes impose new direction for the DOD-NWER&T program. Under this program AFWL is developing theoretical techniques as well as simulators for high-altitude nuclear weapons effects. These include blast and thermal effects, electromagnetic pulses (EMP), X rays, blackout, fireball, and turbulence. The results of this program are of utmost importance to the USAF mission.

The Air Force operational mission is supported by the AFWL nuclear safety program as directed by Air Force Regulations 122-1 and 122-2. Also, AFWL is now the focal point for the Air Force/AEC interface on nuclear weapon conceptual studies, feasibility studies, and development efforts. The direct AF operational support activity of AFWL is an outgrowth of unique laboratory technology programs.

3. MANAGEMENT

a. Organization

AFWL is organized to provide direct control of the mission effort by the Laboratory Commander. AFWL is the only major Air Force laboratory which is manned predominantly by military scientists and engineers and, therefore, provides training and experience in R&D management to a significant fraction of future leaders in Air Force military R&D. Organization of AFWL follows the practice of organizing into functional groupings providing principal emphasis on technical program objectives. Since the Aerospace Industrial Complex has limited capabilities in advanced weapon technology areas of military interest, AFWL manages the significant portion of available expertise in its mission area. To accomplish the AFWL mission objectives, the theoretical and technical

development is planned and developed predominantly in-house; contractor support is utilized primarily for executing experiments or other necessary work developed or specified by in-house efforts. This method has proven to be the most efficient and economic utilization of the limited resources available to accomplish the total AFWL mission.

b. Funds

AFWL has shown a steady increase in funding since its formation. However, there have been drastic changes in sources and application of funds. Nuclear weapons technology has shown a steady growth with AFSC, DNA, and SAMSO being the major contributors. About 50 percent of the total Laboratory funds are applied to this area. Advanced radiation technology has shown a much greater increase in funding levels in recent years but is now leveling off to a slower rate of growth. Increases in civil engineering and environmental research and nuclear safety engineering support are also present; however, funding in these areas represents less than 10 percent of the total Laboratory budget.

c. Manpower

Approximately two-thirds of the Laboratory personnel hold professional degrees. Of our professional personnel, over 15 percent hold PhDs and over 50 percent hold Masters degrees. About 40 percent of our personnel are engaged in various facets of nuclear weapons technology and about 25 percent are engaged in advanced radiation technology, with the remainder being engaged in civil engineering, environmental control, computational services, management and staff. Current authorizations are about 10 percent less than minimum requirements. Laboratory planning is based on a moderate but steady growth. As technology advances, particularly in nuclear weapons and advanced radiation technologies, opportunity for application to existing and conceptual Air Force systems also increases.

d. Air Force Weapons Laboratory Organizational Chart

See figure 2.

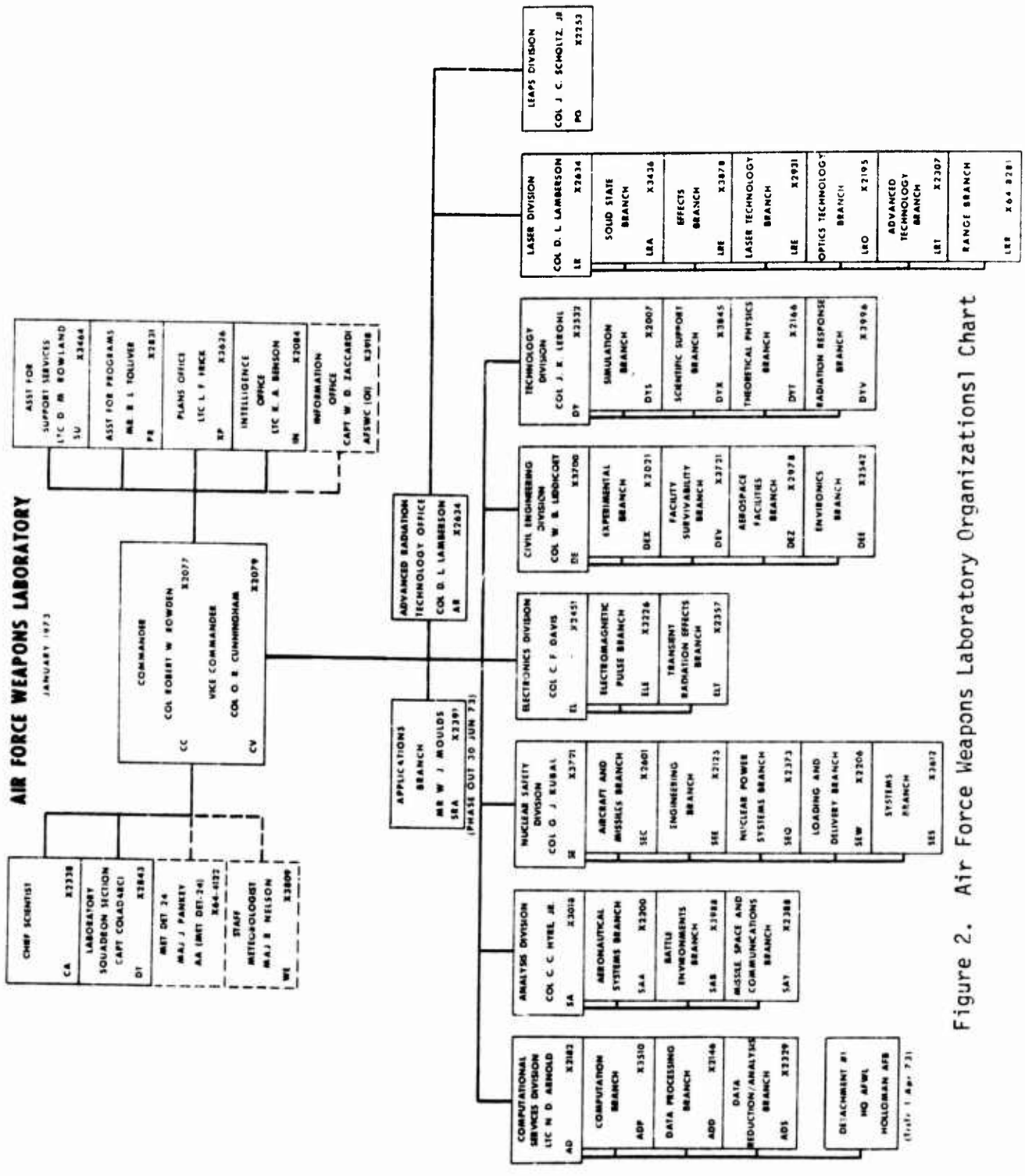

Figure 2. Air Force Weapons Laboratory Organizational Chart

4. FACILITIES

a. Combined Response Simulation Testing (CREST) Facility

This facility simulates the effects of nuclear weapons on materials by impacting them with thin metallic flyers accelerated by magnetic repulsion.

b. Simulation Technology Laboratory

This simulation facility studies the properties and manipulation of high-power electron beams and plasma-focusing devices and associated performance parameters. The laboratory performs work on hot dense-plasma generation and on diagnostics for laboratory simulation of the prompt nuclear environment.

c. Advanced Research EMP Simulator (ARES) Facility

A bounded-wave electromagnetic pulse (EMP) simulator is used to test strategic systems to the effects of EMP.

d. Vertically Polarized Dipole (VPD) Facility

A low-level, vertically polarized omnidirectional wave electromagnetic pulse (EMP) simulator is used to test strategic systems to the effects of EMP and to evaluate theoretical predictions generated through studies.

e. Light Gas-Gun Facility

Research is conducted in the field of materials response phenomenology where materials are subjected to intense shock pulses of short duration.

f. Computation Facility

Computation capability of this facility supports areas including nuclear weapons effects research (NWER) and supporting requirements for Air Force facilities and Air Force operational mission support.

g. Civil Engineering Research Facility (CERF)

Research is performed in structural design criteria required in protective construction and studies are made in air and ground shock required in assessing the survivability/vulnerability limits of strategic structures.

h. Giant Reusable Airblast Simulator (GRABS) Facility

This facility provides high-pressure transient loadings on large structural models imbedded in selected geologic materials. The transient pressure pulse and structure/test-bed configuration can be varied and test-bed motions and structural response are measured during each GRABS experiment.

i. Environics Science and Engineering Facility

Work is performed here on designated projects within the scope of high-quality biological and environmental research.

j. Civil Engineering Instrumentation Laboratory

This laboratory facility builds and checks out digital and analog devices used in acquiring data for Civil Engineering research projects. The laboratory contains equipment for refurbishment and calibration of velocity gages, accelerometers, and airblast transducers. In addition, a time-series analyzer and peripheral equipment is used for playback and analysis of gathered data.

k. Civil Engineering Mobile Field-Data Collection Stations

The inventory consists of instrumentation and field engineering vans and generators with total recording capability of 250 channels.

l. Laser Complex Facility

Technology for laser applications is developed in this facility. It consists of five laser research buildings and associated project offices. This facility contains areas with the capabilities for experimental research in solid-state and liquid lasers, experiments in the chemical kinetics of corrosive and noncorrosive gases, studies of optical components to interface with laser devices, and investigations of beam propagation and effects. A variety of laser devices is used to investigate the physics of pulsed lasers and their applicability to military requirements, to study shock propagation in materials and laser heating of plasmas, to conduct material interaction studies and atmospheric propagation experiments. A pressure-controlled tunnel (200 feet long) is used to simulate atmospheric conditions for propagation experiments. Hardware is being installed for the in-house study of electrical CO_2 lasers to explore the physics of electrical lasers and their effects and propagation characteristics.

m. Sandia Optical Range

The Sandia Optical Range is a field-test complex located at the base of the Manzano Mountains. This range has been developed to conduct tests with high-power lasers and their associated optics under field conditions. The facility incorporates the Air Force laser (AFL) device with associated instrumentation systems, meteorological data-gathering capability, IRIG timing,

communications and data-recording network, and real estate assets. High-power laser propagation studies are performed here over carefully surveyed terrain. This range provides an environment to conduct effects studies under known environmental conditions on materials of interest to the Air Force.

n. Transient Radiation Effects Facility (TREF)

This facility consists of three machines for simulating the prompt gamma from a nuclear burst by using flash X-ray (FXR) machines and a well-equipped electronics laboratory and test facility. The Febetron 705 machine is used for small material samples. Instrumentation is available for conducting experiments in which the electronics under test is fully powered and is being electrically exercised. The test item can be exposed in either a gamma environment or an electron-beam environment. Dose rates can be varied from miniscule rates to rates sufficient to physically destroy the test items. Two large machines are available for the testing of "system size" boxes (i.e., approximately 1-cubic-meter test volume) in a gamma environment. Complete instrumentation for the recording of approximately 96+ channels of data is available. The complete system can be exercised during the radiation tests. Dosimetry is available for determining the delivered dose and/or dose rate. In addition to the gamma mode, one machine can be operated in the electron-beam mode (over a smaller volume) up to energy levels sufficient to destroy typical test samples of systems-associated materials. The second flash X-ray machine will be converted so that it can also operate in the electron-beam mode if desired. A third machine, roughly equivalent to each of the existing ones, is now being assembled. The latest integrated circuit tester and transistor tester are located in the Electronics Laboratory. A scanning electron mirror microscope is available for investigating the surface characteristics of integrated circuits and crystals. A Vanzetti recombination radiation analyzer is available for tracking circuit flow in solid-state circuits, locating hot-spots, and other similar research functions. An automated S-parameter measurement facility is available as well as pulsed-power equipment for investigating the effects of high-intensity, short-duration electrical transients on devices and systems.

o. Pulsed-Power Generation Facility

This facility is used for testing and developing switching techniques as related to large pulsed-power generators, to develop high-voltage diagnostics using electro-optical techniques, and to test various dielectric materials.

p. Two-Mev Flash X-Ray Facility

This facility produces a 2-Mev bremsstrahlung pulse or a pulse of high-energy electrons which is used to study effects on various materials, electronic components, integrated circuits, and simple discrete component circuits.

q. AFWL Los Alamos Electromagnetic Pulse Calibration and Simulation (ALECS) Facility

This facility tests components and/or systems for high-altitude EMP vulnerability and develops and evaluates protective techniques through simulation.

r. Gamma Radiation Facility

This facility is used for experimental research with the dense-plasma focus, the high-energy density system (HEDS) electron beam machine, a high-brightness glass laser, and a CO_2 laser.

SECTION III

AFWL TECHNOLOGY OBJECTIVE NUMBER 3: CIVIL ENGINEERING RDT&E

This effort is to develop methods and techniques for protection of Air Force systems, supplies, equipment, and personnel from nonnuclear attack; to develop a site-selection system for Air Force contingency response as required by DOD; to increase human control of the environment for increased efficiency, effectiveness, and utilization of Air Force resources and to make positive contributions to and develop designs for pollution abatement systems technology in cooperation with Federal and State agencies; to develop techniques and hardware to control and eliminate bird/aircraft encounter; to develop techniques which will improve construction and maintenance of Air Force pavements; to improve efficiency of utility systems required for Air Force facilities; to improve daily operation of Air Force facility support systems; and to improve design and construction management and data-handling techniques for improved effectiveness and decreased cost of operating Air Force facilities.

1. GENERAL OBJECTIVES

The objective of this Advanced Development Program (ADP) is the advancement of aerospace systems basing technology to a level commensurate with support requirements generated in response to advanced aerospace vehicle designs and tactical concepts. Civil engineering technology requirements encompass a broad spectrum of research and development areas which have a direct, immediate impact on the Air Force's ability to support tactical and strategic operations worldwide. The goal of this development program is the assurance that the United States Air Force has available the latest and most scientifically advanced techniques and equipment to provide facilities support for its operation.

a. Control of Noxious Effluents (CONE)

The CONE program is an outgrowth of the need to answer environmental problems related to aerospace operations. It is aimed at identifying the emissions and quantity of pollutants from USAF aircraft and missiles and support operations, and tends to be an air resources-oriented program. It is aimed at studying methods and instrumentation for measurement of pollution

levels, environmental impact of aircraft pollutants and support operations, and control and disposal technology for meeting environmental quality standards and criteria. Approach will include (1) impact of AF aircraft emissions on environmental quality, (2) effects on air quality from fuel dumping and venting, (3) afterburner emission measurement system, (4) Environmental Impact Statement support and consultation to weapon systems, (5) aircraft pollution emission factors and operation, (6) Climatic Impact Assessment Program (DOT) support, (7) (7) catalytic combustor development, (8) community effects from sonic booms, (9) jet engine test-cell pollution control, (10) evaluation of environmental quality of AFFTC before, during, and after operation of high-performance (B-1, F-15) aircraft, and (11) environmental protection and evaluation of pollution problems associated with missile launch operations.

b. Bird-Aircraft Strike Hazards (BASH)

USAF aircraft have experienced an increasing number of bird strikes in aircraft windshield areas, causing significant numbers of aircraft losses including at least one F-111. The protection of additional possible losses emphasizes the need for an integrated effort to solve this problem. Consequently, Hq USAF has requested a development plan for a windshield protection program applicable to all current and future military aircraft. This program addresses the immediate F-111 bird-strike program as well as a longer-range program applicable to all aircraft. The longer-range development program will produce design manuals which will enable cockpit inclosures to be designed to any level of protection desired and indicate to system managers the trade-offs associated with various levels of protection. Operating commands will be provided with data to permit bird-hazard avoidance through flight routing and scheduling. Also included in these efforts are programs to define bird migration routes, to control birds near airports, and to develop windshields to withstand bird impacts.

2. SPECIFIC GOALS AND TECHNICAL APPROACHES

The specific task areas in which research and development efforts will be conducted include air base vulnerability/survivability, environmental engineering technology, aerospace vehicle landing-surface compatibility, and mission support systems. Each task area represents a broadbased continuing effort; therefore, the technical approach planned for each area is discussed in the following subsections.

a. Air Base Vulnerability/Survivability

The objective of this task is to consider vulnerability and improved survivability of the air base complex. Improved design criteria for structures to meet tactical aircraft protective requirements must be developed and methods of providing protective shelter for larger aircraft must be investigated. These protective structures include revetments, shelters, and associated closure systems erected in various sizes and shapes for uses other than aircraft shelters. Efforts also include camouflage techniques, additional protective covers, and foreign shelter evaluations. Methods must be developed for rapid repair of bombed airfield pavements or alternate methods of aircraft moving. Considerations will include methods of bomb damage repair based on present equipment and technology and also methods that will meet stringent operational time requirements. The development of improved design criteria for soft structures to meet air-mobility requirements will include the foam-in-place shelter and other required research for air-mobility shelters.

b. Environmental Engineering Technology

The objective of this task is to develop methods and techniques for detecting, controlling, and abating Air Force unique environmental pollution problems and evaluating the environmental impact therefrom. It includes those environmental problems which interfere with Air Force mission accomplishment or which result from mission performance. The technology area includes a research and exploratory and advanced development effort as well as a consultation program in the areas of water and waste-water resources, solid and air resources and ecosystems technology including bird/aircraft strike hazards. Specifically, these efforts include improved treatment and disposal techniques for Air Force industrial wastes, smoke abatement methods for crash-rescue training operations, control of pollution from jet engine test cells, Air Force pollution emission factors, solid waste recovery and recycling, control of birds in the airport environment, noise exposure, and land-use planning techniques and pollution-monitoring instrumentation and environmental-impact analysis and evaluation.

c. Aerospace Vehicle Landing-Surface Compatibility

The primary objective of this task is the development of new and improved evaluation, maintenance, and repair techniques for surfacings required to support aerospace vehicles. At military bases throughout the world, the

base civil engineer has the responsibility for providing and maintaining surfaces ranging from flexible and rigid pavement systems on the larger bases to austere landing-mat and bare-soil surfaces for the theatre of operations. New aerospace vehicles are being developed which require operational surfaces beyond existing capabilities. Upgrading and maintaining the existing 200 million square yards of Air Force operational surfaces require extensive research for more efficient and effective methods of evaluating the roughness, surface traction, load-carrying capacity, and the degree of distress of these surfaces. Based on this research, decisions and forecasts can be made regarding the method and material required for properly maintaining these surfaces. Criteria for new materials, surfacings, and methods for upgrading existing surfacing systems must be developed. The scope of this task area is broad and is intended to include all major problems facing the Air Force civil engineer in the area of soils and pavements and their compatibility with aerospace vehicles. The specific activities are grouped as follows:

Airfield surface management
Simulated evaluation
Physical evaluation
Improved maintenance techniques
Materials and repair techniques
Expedient airfield surfacing
Soil stabilization

d. Mission Support Systems

This task will provide the engineering and materials technology required by the base civil engineer for maintaining the facilities and utilities required to support Air Force operations. Reliability of electric power sources will be investigated to produce economic and efficient designs which are appropriate to a wide variation of Air Force facilities. POL storage and distribution systems will be investigated to improve performance and safety characteristics. The development of corrosion control techniques and equipment for fixed and mobile power plants, heating and cooling systems, and POL systems will be continued. Improved fire detection and extinguishing techniques for aircraft hangars and warehousing facilities are also included in this task area.